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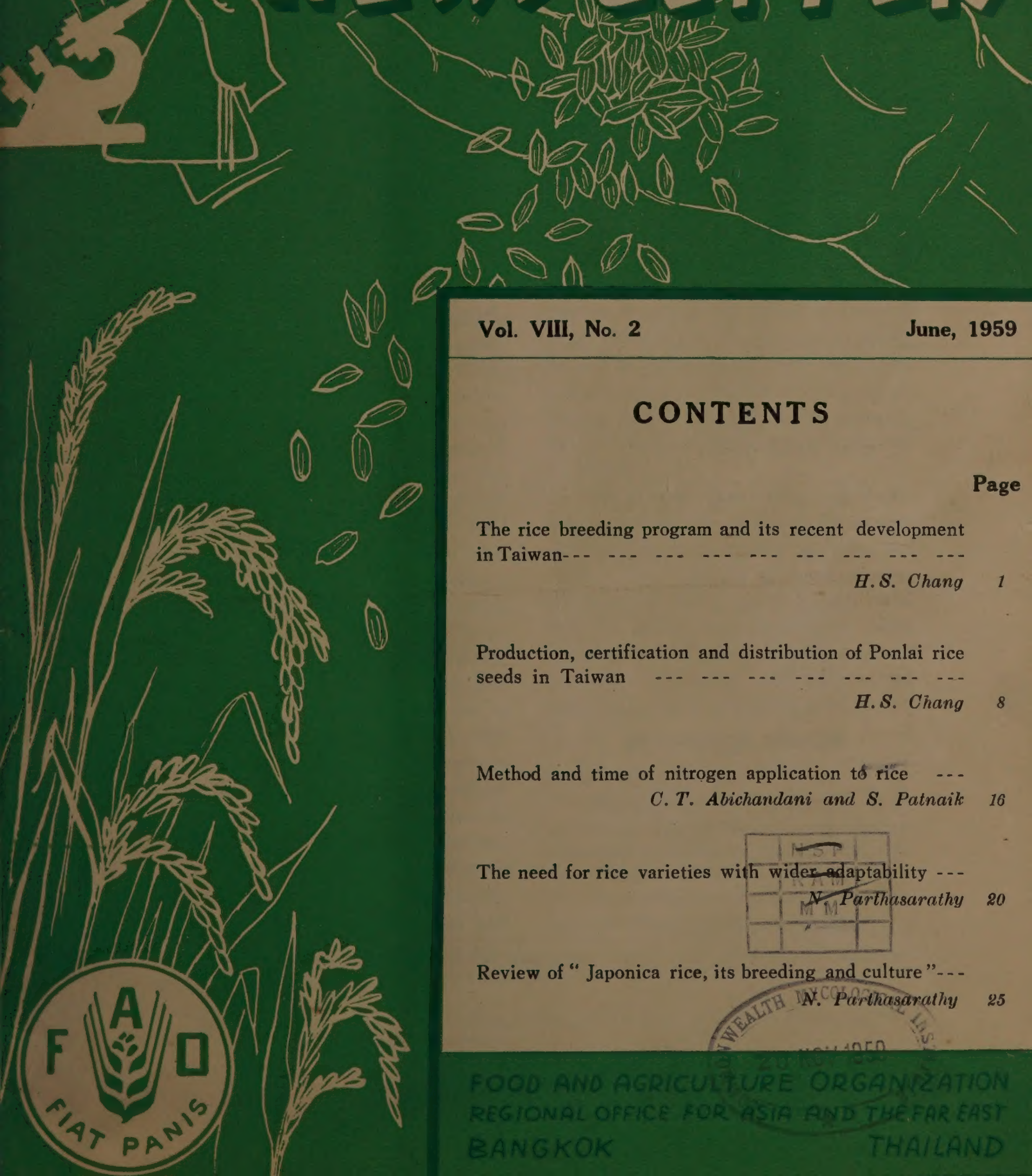

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CONTENTS

FOOD AND AGRICULTURE ORGANIZATION
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THE RICE BREEDING PROGRAM AND ITS RECENT DEVELOPMENT IN TAIWAN[1]

H. S. Chang[2]

INTRODUCTION

In the early days, the rice varieties of Taiwan were mostly of *indica* type. During the Japanese occupation, efforts had been made by the Japanese agriculturists to improve the local rice varieties. Japanese rice varieties were then introduced to Taiwan for planting. These introduced rice varieties of the *japonica* type are locally know as Ponlai rice. Owing to its better quality, higher yield, shorter growing period, and non-sensitivity to photoperiod, the Ponlai rice began to gain a firm footing on the Island. Among the early introduced Ponlai rice, Nakamaru was the leading variety. Its acreage in Taiwan once reached 106,689 ha. before 1926. Through local hybridization work in Ponlai rice, new varieties gradually came into being, among which "Taichung 65" has been the most prominent one ever produced. It is an offspring of a cross between Kameji and Shinriki, developed by the Taichung District Agricultural Improvement Station in 1929. Because of its good quality, high yield and wide adaptability, it replaced rapidly Nakamaru as well as the native *indica* type of varieties, and became the most widely planted rice variety in Taiwan.

In postwar years, rice breeding work has been carried out by all the District Agricultural Improvement Stations and considerable progress has been made especially on Ponlai rice, including round glutinous rice. New varieties from all district stations have gradually replaced Taichung 65. In 1941, the acreage of Taichung 65 was 118, 692 ha. (or 69.45% of the total acreage) in the first rice crop or spring crop and 119, 704 ha. (65.5% of the total acreage) in the second rice or fall crop, while in 1958, it dropped to 48,681 ha. and 48,834 ha., being 21.1% and 18.86% respectively of the total Ponlai rice acreage. Among the existing Ponlai rice varieties, 20 varieties are being most widely planted by farmers.

The postwar government policy has been, until recently, to extend the acreage of Ponlai rice at the expense of native rice because the former is of better quality, yields higher, and of higher export value. For this reason, rice improvement work and seed multiplication were concentrated on Ponlai rice, while such work on the native and upland rice was rather neglected.

RICE BREEDING PROGRAM

A. Breeding Stations

Rice breeding work is carried out by the Taiwan Agricultural Research Institute and all seven District Agricultural Improvement Stations. The names and locations of the organizations engaged in rice improvement program are listed as follows:

[1] Paper presented at the Second Far East Seed Improvement Conference, sponsored by International Cooperation Administration, U.S.A., held at Tokyo, Japan, 11-30 May 1959.

[2] Specialist, Plant Industry Division, Chinese-American Joint Commission on Rural Reconstruction, Taipei, Taiwan.

Organization	Location	Breeding Programs Conducted
1. Taipei District Agricultural Improvement Station (Taipei DAIS)	Taipei (Northern Taiwan)	Ponlai rice
2. Hsinchu DAIS	Hsinchu (Northern Taiwan)	Ponlai rice
3. Taichung DAIS	Taichung (Central Taiwan)	Ponlai rice; native rice; glutinous rice; blast resistance
4. Tainan DAIS	Tainan (Southern Taiwan)	Ponlai rice; upland rice
5. Kaohsiung DAIS	Pingtung (Southern Taiwan)	Ponlai rice
6. Taitung DAIS	Taitung (East Taiwan)	Ponlai rice
7. Hualien DAIS	Hualien (East Taiwan)	Ponlai rice
8. Taiwan Agricultural Research Institute (TARI)	Taipei (Northern Taiwan)	Ponlai rice; inter racial cross between *japonica* and *indica* rices; Genetic and Cytogenetic studies.
9. Chiayi Experiment Station, TARI	Chiayi (South Central Taiwan)	Blast resistance of Ponlai rice

B Rice Breeding - Main Objectives

1. To breed blast resistant varieties: Rice blast is one of the main diseases which annually causes considerable losses in Taiwan. Particularly in the first rice crop, the disease is very prevalent in Ilan, Chiayi, Kaohsiung and East Taiwan areas. The breeding of blast resistant variety, therefore, is one of the most primary aims in rice breeding.
2. To breed varieties with high yielding capacity: Breeding of varieties for high yield is the universal aim of all breeding programs. Under the circumstance of limited arable land and steadily increasing population in Taiwan, it has special practical significance.
3. To breed varieties with good milling and table quality: The bulk of rice produced here in Taiwan is for domestic consumption, but about 10% of it is exported to other countries, chiefly, Japan. In recent years, the competition in the world rice market has become much keener than a few years ago, and the need for Taiwan to produce rice of high quality is more pressing. So the factor of good milling and table quality becomes an important aim of the future rice breeding program.
4. To breed varieties of wide adaptability: Wide adaptability is a very important character to be taken account of in rice varieties. Among the rice varieties now being grown in Taiwan, "Taichung 65" is so far still the most widely adaptable one. Some of the new varieties released in recent years have proved superior to "Taichung 65" in yield, but their superiority is limited to particular localities. The extension of these varieties has been effective in raising the yield of rice, but has

resulted in a larger number of extension varieties than before, each covering a smaller area. Emphasis is therefore to be placed on wide adaptability in rice breeding, with the hope that the varieties under extension may be reduced.

5. To breed varieties of shorter growing period: One of the superior characteristics of the Ponlai rice is its shorter growing period. In recent years, more and more farmers have adopted a cropping system under which a summer crop, a winter crop or both are planted in between the spring or the first rice crop and the fall or the second rice crop in order to get more out of the limited acreage of arable land. This could be illustrated by the winter soybean crop, which is planted after the second rice crop in Kaohsiung area and the summer planting for melons and winter planting of wheat in Taichung area, both of which are planted in between the two rice crops. With this extremely tight cropping system, rice varieties of shorter growing period naturally have definite advantages.
6. To breed stiff strawed varieties with responsiveness to higher levels of fertilizer applications: In the last ten years, the rate of fertilizer application on rice crop has been increasing considerably. The rate of fertilizer application in 1958 was $N=90$ kg., $P_2 0_5=35$ kg., $K_2 0=18.6$ kg., per hectare. Increases in the level of nitrogen application not only bring about lodging, but also increase the susceptibility of the crop to blast, and hence the necessity to breed varieties which could respond to heavy fertilization and having the characters of non-lodging and blast resistance.

C. Materials for Rice Breeding

The breeding materials commonly used in Taiwan are the native *indica* type varieties, the local rice varieties grown by the aborigines in mountain area, the Japanese rice varieties and locally bred Ponlai rice varieties. In recent years, rice varieties introduced from the Mainland China and those from South Eastern Asian countries have also been included in the collection. In some stations, rice varieties brought from the United States are also being used as breeding material.

D. Rice Breeding Procedures

The breeding of rice varieties is usually carried out in two ways:

(1) Hybridization - commonly used for Ponlai, native and upland rice breeding, and

(2) Pure line selection - used for improving native rice and upland rice.

1. Hybridization

a. Crossing is usually made between native and Ponlai rice varieties and in most instances multiple cross is used. The F_1 plants of the crosses are utilized. The F_2 and F_3 strains possessing desirable characters of both parental materials are selected. From F_3 to F_5, selection is continued and homozygous lines are selected from F_6 for the preliminary yield test.

b. Preliminary yield test: The preliminary yield test is conducted under two fertilizer levels: One with a normal rate of fertilization and the other with twice the normal rate. The field layout is in 2-to 3-row -plot, randomized block with two to three replications. Field notes on the following are taken:heading, maturity, degree of infection of blast and other diseases, height of plant, tillering, length of head, awn, shape of kernel and number of kernels per head. The preliminary yield test is continued for four crop seasons. The offspring from a cross is sometimes crossed with other varieties, and so in many cases, the parent stock consists of more than two varieties.

c. Advanced test: The strains selected from the preliminary test are put into the advanced test, in which 5-row-plot, randomized arrangement is adopted with 4 replications. After 4 crop seasons in the advanced test, the desirable strains are selected by the breeding station for either of the following two tests, viz. district regional test or provincial regional test.

d. District regional test: The strains released from the advanced test of the breeding station are recommended by the station to the Rice Improvement Conference (RIC) convened semi-annually by the Provincial Department of Agriculture and Forestry. The function of the conference is to determine the varieties to be included in the District Regional Test, Provincial Regional Test, Demonstration Farms and the Foundation Seed Farms. After the varieties are approved by the said meeting, they will be included in the District Regional Test in which 5-row-plot, randomized block with4 replications will be followed. The number of varieties in the District Regional Test does not usually exceed 16 in number.

The number of tests within each district is to be decided and recommended by the respective District Agricultural Improvement Station and approved at the Rice Improvement Meeting, but the total number of places of the District Regional Test in the whole province of Taiwan stays around 50. Every two years, the question of replacing partly or wholly the varieties used in the District Regional Tests will be considered.

e. Provincial regional test: From the advanced test, promising varieties which show possibilities of wide adaptability may be picked out for Provincial Regional Test which is conducted by the Taiwan Agricultural Research Institute to find out their adaptability on a province-wise basis. The recommendation is to be made by the breeding station and approved by the Rice Improvement Conference of PDAF. Under the Provincial Regional Test, 5-row-plot, randomized arrangement with 5 replications, will be used. The varieties in the Provincial Regional Test are usually

from 16 to 20. The test should be conducted at not more than 10 places scattered in the whole province. Replacement of the varieties with newer and promising varieties partly or wholly will be considered once in three years. The varieties bred by other stations but showing superiority in the Provincial Regional Test at anystation should be included into the District Regional Test carried on by the District Agricultural Improvement Stations along with varieties selected from their own advanced tests.

f. Demonstration: Promising varieties chosen from the District Regional Test are put into the Demonstration Farms within the district for demonstration purpose before starting seed multiplication and extension.

g. Multiplication: Varieties after being demonstrated in demonstration plots for a year are multiplied through the three levels of seed farms: i.e. the foundation seed, stock seed and extension seed farms, to produce seeds for extension.

2. Pure line selection

This is carried out among widely adapted varieties. In the beginning, head selection is practised. The heads selected are put into the head row test, in which seeds of each head are planted in a row of 1 meter long. Direct sowing method is used, The selected seeds are put into the 2-rod-row test for further screening and selection. In 2-rod-row test, the plants are spaced 25 cm. and 20 cm. between rows and hills. Each row is 4 m. long consisting of 20 hills and five plants planted in a hill, with a check after every fifth row. The strains selected from 2-rod-row test are further screened in the 5-rod-row 10-rod-row test, in both of which the same design as in 2-rod-row test is used. Strains chosen from 10-rod-row test are tested in the advanced test. In the advanced test, 5-row-plot, randomized arrangement with 6 replications is used. The spacing and length of row are the same as those in 2-rod-row test. The test is usually be continued for 2 years, and the desirable strains released for District Regional Test.

It is to be noted that breeding procedures used are conventional. Only the coordination between the District Regional Test and the Provincial Regional Test is a special feature adapted to the organizational relationship of the District Agricultural Improvement Stations and the Taiwan Agricultural Research Institute. This coordination system was established by organizing a Rice Improvement Conference under Provincial Department of Agriculture and Forestry since the spring of 1956. In this meeting, all plant breeders in the various district stations are invited to attend for exchange of information on breeding materials, discussion of breeding results and screening of the recommended varieties to be included into the District Regional Test, Provincial Regional Test, Demonstration Farm and Foundation Seed Farms. Under this closely coordinated plan, the promising varieties selected from the advanced tests of the various breeding stations are included for further test (either in District or in Provincial Regional Test) and the less desirable varieties are discarded. Furthermore, a unified breeding program is achieved.

Apart from the hybridization and pure line selection methods described above, backcross method is also frequently used in the course of breeding of disease resistant varieties, particularly for blast resistance.

In addition to the conventional breeding methods described in the foregoing paragraph, irradiation of rice seeds for inducing mutations has also been taken up since 1955 as a new tool in the rice breeding program in Taiwan.

E. Recent Development of Rice Breeding

1. Breeding for blast resistance

As the blast disease is the most persistent and destructive disease of rice in Taiwan, particularly in the first rice crop, causing an annual loss estimated not less than 5% of total production, emphasis has been placed on the breeding of blast resistant varieties in rice varietal improvement program. Furthermore, the susceptibility of the existing Ponlai rice varieties to this disease is limiting the expansion of Ponlai rice acreage and the increased application of N fertilizer on rice.

Systematic breeding work for blast resistance has been started since 1950. Crosses made between Ponlai rice varieties *(japonica)*, Ponlai rice and native rice varieties *(indica)*, Ponlai rice and mountain varieties originally introduced from Malaya and Philippines and also between Ponlai rice and glutinous rice varieties at various agricultural stations in Taiwan. The varieties selected to make crosses possess either desirable agronomic characters or resistant character to blast. "Taichung 65", being the most popular variety in Taiwan, valued as a high yielder with wide adaptability and good quality grain, was, therefore, most extensively chosen as parental material in making crosses.

In the methods of breeding, pedigree, bulk and back cross are employed. Two or all three methods may be used in different generations after a cross is made. Furthermore back crosses are frequently made with Taichung 65 as recurrent parent. In inducing infection of blast disease on the progenies, at first, only artificial inoculation method was used during the seedling stage. Later, it was found that the reaction of the variety to blast in growing season differed from that in the seedling stage. Therefore, from 1952 to 1954, certain spots near the hill side of Tungshih, Taichung Prefecture, where natural conditions for the infection of blast disease are very favorable, were chosen to set up experiment fields on which the progenies were planted for observation on resistance to blast. Besides the favorable natural environment to the blast infestation, very heavy applications of nitrogenous fertilizer (160 kg. of nitrogen per hectare) were made in the experimental plots to make the condition even more favorable for blast infection.

In making observation of the leaf blast, 12 classes of disease development in leaf blast phase are established, varying from "no diseased leaf surface" to complete infection of the entire plant. These standards are being used to rate the degree of leaf blast development on rice plant.

Since the first crop of 1956, a number of established varieties were planted in blast disease prevalent areas in 4 localities of Taiwan to observe the reaction to blast disease. The results obtained from 1956-1958 revealed that rice varieties show great deal of difference in resistance with respect to variety, locality and year.

The physiological strains of the causal organism has been studied since 1957 for determining the presence of such strains.

Irradiation of Ponlai rice seeds with X-ray, Cobalt 60 and thermal neutrons have also been made to induce mutants which may be resistant to rice blast. Among the treated progenies, a few are found to be quite resistant. The preliminary results are encouraging and observation and further tests are still underway.

The varieties relatively resistant to blast disease developed in Taiwan are listed as follows:

Variety	Parental stock	Percentage of diseased leaf surface
Chia-nung 242	(Hsinchu 4 x Taichung 150) x (Taipei 7 x Tainung 45)	0.2-5%
Taichung 178	Taichung Glu. 46 x Yoshino	11%
Taichung 179	Kwangfu 401 x Kwangfu 1	5%
Kaohsiung-yu 71	(Chianan 2 x Ladang Paeboeboe) x Kaohsiung 18	5%

2. Application of irradiation treatment for induced mutants

Irradiation of rice seeds with X-ray and Cobalt 60 for induced mutation was started from 1955 in Taiwan. Again in 1957, seeds of five Ponlai rice varieties were sent to the Brookhaven National Laboratory, Long Island, New York, U.S.A., for irradiation treatment by X-ray (20,000r and 25,000r) and thermal neutrons (15 hours and 20 hours). Treated seeds were sent back to Taiwan for experimentation. Among the treated progenies, disease resistant (several are found resistant to blast, two strains are resistant to Helminthosporium and a few others resistant to Corticium sheath rot), early maturing (five to ten days earlier than the untreated varieties), stiff straw, and large panicle strains are found.

Irradiation treatment seems to be quite encouraging for obtaining desirable mutants, particularly in the breeding for disease resistance although the results are not yet conclusive.

3. Breeding of promising native (indica) rice varieties

The improvement work on native rice was started from 1949. Five crosses were made between the local breeding stocks by the Taichung District Agricultural Improvement Station. In 1957, a new promising rice variety, Taichung Native No. 1. was developed. This variety, though an *indica* rice, has many desirable characters. As this variety is less sensitive to photo-periodism than other *indica* varieties in Taiwan, it can be successfully planted in both the spring and the fall crop .It is of stiff straw, responsive to fertilizer application and also a good yielder.

It is predicted that this variety will become more and more popular in regions where native rice is being grown.

CONCLUSION

In summarizing the recent progress of rice breeding made in Taiwan, it may be stated that the popular Ponlai rice varieties released in the earlier period have

been largely replaced by varieties bred in the postwar period. The acreage of "Taichung 65" in the first and second crop of the past few years dropped considerably. Among the new varieties recently developed, Chia-nung 242, a cross of Chia-nung-yu 65 and Chia-nung-yu 123, released by the Chiayi Agricultural Experiment Station has been found rather promising in Taichung, Tainan and East Taiwan areas for its blast resistance, high yield and wide adaptability. Kaohsiung 45 and Kaohsiung 53 have made very good performance in the Kaohsiung area, while Hsinchu 55, and Hsinchu 56 have shown good results in the Hsinchu area, and Taipei 127, Taipei 177 in the Taipei area. These varieties are being planted in the demonstration farms in various districts for demonstration and extension.

The new varieties to be developed in the future would be of early maturing, good quality, high resistance to blast and tolerant to heavy fertilization without lodging, and of good yielding capacity so that they would be able to fit into the tight cropping schedule now being practised in Taiwan. With the recent development of breeding technique as well as the application of irradiation treatment on crop seeds together with the more thorough genetic studies on rice and expansion of breeding stock, new varieties having the desirable characters will be developed in the future.

PRODUCTION, CERTIFICATION AND DISTRIBUTION OF PONLAI RICE SEEDS IN TAIWAN[1]

H.S. Chang[2]

INTRODUCTION

In Taiwan, there are two main paddy rice groups under cultivation, i. e., the Ponlai rice group (*japonica*) and the native rice group (*indica*). The Ponlai rice is a common name for the improved varieties of the *japonica* type including both the pure-bred varieties introduced from Japan and the offsprings from the inter-crossing of the introduced Japanese varieties or from their crossing with the native rice in Taiwan. The Ponlai rice is of stiff straw, short and round kernel, non-sensitive to day length, responsive to fertilizer, early maturing and a high yielder and so it is favorably accepted by the farmers.

Although there are 127 established Ponlai rice varieties for the spring crop (or first rice crop) and 131 varieties for the fall crop (or the second rice crop), only 20 varieties are being widely planted in both spring and fall crop. It has been the policy of the Government to encourage the farmers to plant Ponlai rice in place of the native

[1] Paper presented at the Second Far East Seed Improvement Conference, sponsored by International Cooperation Administration, U.S.A., held at Tokyo, Japan, 11-30 May 1959.

[2] Specialist, Plant Industry Division, Chinese-American Joint Commission on Rural Reconstruction, Taipei, Taiwan.

rice. The extension of irrigation facilities, chemical fertilizers and pesticides to farmers has decisively helped the expansion of its acreage in recent years. In 1958, the Ponlai rice acreage was 460,596 ha., being 59.2% of the total rice acreage (778,189 ha.). Its production reached 1,185,342, M/T of hulled rice (brown rice) which was 62.6% of the total production (1,894,127 M/T of brown rice). The acreage and production of the *indica* rice in the same year were 274,508 hectares (36.3% of total) and 644,262 M/T (34% of the total) respectively.

In Taiwan, the rice seed multiplication system was established before the Second World War. Since 1945, efforts have constantly been made firstly to rehabilitate and then to strengthen the system of rice seed production and distribution which was largely broken down towards the end of the War. The more recent improvement covers: (1) the reduction of the number of extension seed farms (Certified Seed Farms) from 7,000 to less than 3,000 for better management; (2) the provision of needed facilities for all seed farms; (3) a more adequate supervision over the multiplication of pure seeds; (4) the establishment of a system in approving new varieties for multiplications and distribution; and (5) the adoption of a rice seed certification system.

1. Present Seed Production System

A. Kinds of seed farms

The production of pure rice seeds in Taiwan follows the normal pattern adopted by most other nations. It consists of three levels, i.e., the Foundation Seeds, the Stock Seeds (equivalent to the Registered Seeds) and the Extension Seeds (equivalent to Certified Seeds). The procedure followed in the seed production program is as below:

1) The Rice Improvement Conference. The Rice Improvement Conference (RIC) convenes once or twice a year. The RIC is a working party under the Provincial Department of Agriculture and Forestry (PDAF). In the conference, where all the rice breeders in various experiment stations attend, the rice breeding program, the varieties for regional test, for demonstration and for extension, and other important problems on rice varietal improvement are discussed and decision reached. The resolutions made at the conference are to be carried out by various stations and local governments and farmers' associations accordingly. The rice varieties approved by RIC for multiplication and extension are included in the seed production plan for the ensuing season.

2) Foundation seed farm. Following the resolution of RIC, the foundation seed farms will receive the breeders' seeds of the approved rice varieties from the breeding stations. In order to maintain the genetic identity and purity of the variety, the foundation seed farm is managed with utmost care. The seedbed is observed carefully. Any off-type or plant in question is rogued. In transplanting, only one seedling is transplanted into each hill for the convenience of close field observation. As the purpose of the foundation seed farm is to produce seed of high purity and quality, the projected yield is set at a fairly low level, 1,500 kg/ha. (The average yield of rice crop in 1958 was 3,158 kg. of paddy per hectare.) Under the normal rate of seedling (60 kg/ha.), this amount of seed produced will be enough for planting 25 hectares of stock seed farms (registered seed farms) the following season. Since

the management of the foundation seed farms requires intimate knowledge of the genetic characters of the varieties under multiplication, the seven District Agricultural Improvement Stations under the administration of the PDAF on the island are charged with the responsibility. The foundation seeds are supplied free of charge to the stock seed farms.

3) **Stock seed farm (registered seed farm).** The foundation seed is used for seeding the stock seed farms at a rate of sixty kilograms per hectare. The operation of the stock seed farm is also carefully managed. But in line with the farmers' practice, 4-6 seedlings are transplanted to a hill, instead of one seedling transplanting as used for foundation seed farms. The projected average yield of a stock seed farm is 2,400 kg/ha., an amount enough to plant forty hectares of extension seed farms. The stock seed farms may be operated by the local prefectural government, farmers' association or contracted farmers under their supervision. The stock seeds produced are bought up by the prefectural government and given, without charge, to the extension seed farms for further multiplication.

4) **Extension seed farm (certified seed farm).** The third step of the seed production system, the extension seed farms receive their seed supply from the stock seed farm. The extension seed farms should also be well managed. Roguing should be done four times in the first crop and three times in the second crop, to eliminate barnyard grasses, off-types and other mixtures that may be present. The size of extension seed farms, which are scattered in all rice growing townships, should not be smaller than half a hectare. The projected yield of an extension seed farm is the same as that of a stock seed farm. This amount, 2,400 kg. per hectare, is enough to plant forty hectares of farmers' paddy field. The extension seed farms are operated mostly by contracted farmers.

The pure seeds produced from the extension seed farms may be obtained by the rice farmers by exchanging with their own seed either at the rate of one to one or at a premium of not more than 20 per cent. This exchange usually takes place at the extension seed farms.

5) **Summary of the seed farms.** A summary table showing the system of rice seed production now being practised in Taiwan is given as follows:

Seed Farm	Source of seed supply	No. of plants per hill	Projected yield kg/ha.	Operated by	Location
Foundation Seed Farm	Breeder's seed plot	Single plant	1,500	District Agricultural Improvement Station	District level
Stock Seed Farm	Foundation Seed Farm	5 plants	2,400	Government Agencies and Farmers' Associations	Prefectural level
Extension Seed Farms	Stock Seed Farm	5 plants	2,400	Contracted farmers	Township and village level

B. Number of seed farms and amount of seeds produced

There are 12 foundation seed farms, 184 stock seed farms and 5,112 extension seed farms for two rice crop seasons in Taiwan. The amount of foundation seeds, stock seeds and extension seeds produced in 1957 was 14,816.6 kg., 267,420 kg. and 9,747,922 kg. respectively. Every year in the fall season, the PDAF will set the projected goal of seed production for the following year. This goal is so adjusted that enough pure seeds will be multiplied to supply at least 1/6 of the total Ponlai rice acreage. As the total Ponlai rice acreage in Taiwan is around 450,000 ha., the projected acreage is set to produce 5,700,000 kg. of pure seeds which is enough to supply 95,000 ha. of paddy field. Under the double cropping system, most of the paddy field is planted to rice crop twice a year so that each field will have the chance to receive pure seeds once every three years. The number of seed farms and projected amount of pure seeds to be produced in 1959 are listed in the following table:

	First Crop			Second crop			Total		
	Number	Acreage (ha.)	Projected amount (kg.)	Number	Acreage (ha.)	Projected amount (kg.)	Number	Acreage (ha.)	Projected amount (kg.)
Foundation Seed Farm	5	1.3	1,950	7	3.20	4,530	12	4.32	6,480
Stock Seed Farm	73	24.81	102,744	111	47.11	113,064	184	89.92	215.808
Extension Seed Farm	2,160	802.75	1,926,600	2,952	1,572,25	3,773,400	5,112	2,375.00	5,700,000

2. Seed Certification

The Ponlai Rice Seed Certification System was inaugurated in Taiwan in 1957. The year before, when the First Far East Seed Improvement Conference (FESIC) sponsored by the International Cooperation Admininstration (ICA) was held in Taipei, Taiwan, discussions related to the development of seed technology (seed processing, seed analysis, seed storage and seed marketing) in the Far East Asian countries. The resolutions made in the FESIC are summarized as the following.

a. ICA/Washington be requested to make arrangement with some leading organizations on seed technology to offer special course on seed technology to trainees from FESIC countries.

b. FESIC countries should take necessary action toward the establishment of seed laboratory as the first step in the development of seed technology.

c. ICA/Washington be requested, at appropriate time, to set up seed technology training centre in FESIC area to offer training courses, to conduct research and to furnish information and services toward seed technology.

Pursuant to the seed conference, the Chinese Government in Taiwan has approved the recommendations made by the

Agricultural Association of China (an organization of Chinese agricultural research workers and educationists), to establish the seed certification system of rice and other farm crops and to set up two seed laboratories in Taiwan, one in the National Taiwan University for research and training purposes and another under the PDAF to handle actual seed certification program.

Subsequently with technical and financial assistance from the Joint Commission on Rural Reconstruction (JCRR), seed standards and procedures were prepared and adopted by the PDAF and the Ponlai Rice Seed Certification system was inaugurated in Taiwan in 1957.

A. Ponlai rice seed certification standards

The certification standards of Ponlai rice seed consist of field standards which are to be followed in field inspection and seed standards to be followed in laboratory analysis. The field and laboratory certifying standards for different seed farms are listed in the following table:

Ponlai Rice Seed Certification Standards

(1) Field standards:

Factor	Maximum permitted in each class of seed farm: Foundation	Stock	Extension
Other varieties	None	None	None
Barnyard grass	None	None	None
Objectionable weeds	None	None	10 plants per 1,000 sq. m.
Disease affecting quality of seed or transmissible through planting stock	None	None	None

(2) Laboratory standards:

Factor	Standards for each class of seed farm: Foundation	Stock	Extension
Pure seeds (minimum)	99,8%	99.5%	99%
Inert matter (minimum)	0.2%	0.5%	1%
Other varieties (maximum)	None	None	25 seeds per kilo
Barnyard grass (maximum)	None	None	5 seeds per kilo
Weed seeds	None	None	2 seeds per kilo
Germination (minimum)	90% (1st crop) 85% (2nd crop)	90% (1st crop) 85% (2nd crop) 80% (Intermediate crop)	90% (1st crop) 85% (2nd crop) 80% (Intermediate crop)
Moisture content (maximum)	13%	13%	13%

In addition to field inspection and laboratory analysis, the storage inspection is also needed to determine whether, (1) the storage facilities are available, (2) proper care be taken to clean the stores before seeds are stored, (3) the storage facilities are adequate to prevent rats and insects, (4) the stores are affected by outside humidity, and (5) the germination percentage is affected by long period of storage, etc.

B. Operation of the seed certification system

The certification of rice seeds includes the field inspection, storage inspection and laboratory analysis. The field inspection covers all classes of seed farms whereas the storage inspection and laboratory analysis cover all the foundation seed farms, stock seed farms and so far only a part of the extension seed farms. In 1957, only 113 extension seed farms were sampled at random for laboratory analysis. From 1958 to 1959, one third of the extension seed farms have been scheduled to undergo laboratory analysis.

In making field inspection, inspectors will be dispatched to the seed farms from full heading stage to dough stage to carry out field inspection work. The foundation seed farms will be inspected by inspectors from the Taiwan Agricultural Research Institute (TARI). The stock seed farms will be inspected by inspectors dispatched from District Agricultural Improvement Stations (DAIS) and Prefectural Government. The extension seed farms will be inspected by inspectors from the township office with the assistance of DAIS.

In making laboratory analysis, the TARI will dispatch personnel to the DAIS to take seed samples (2 kg. each) from foundation seed farms and bring them back to its laboratory for seed analysis. For the stock seeds, the DAIS will dispatch personnel to take seed samples and bring them back to the station for seed analysis. If a sample is found up to the standard, the respective seed farm will be informed and tags will be issued (white tags for foundation seed farm and purple tags for stock seed farm) to indicate these seeds are certified according to government regulations. For the extension seeds, no tags will be issued to the operators. Instead, a certificate notice, on which the name of the operators, name of the variety, amount of seeds produced and quality of seeds, shall be written, and posted at some public place in the township.

The results of seed certification of the three classes of seed farms in the first and second crops of 1958 are given as follows:

	Field inspection 1st crop	Field inspection 2nd crop	Laboratory analysis 1st crop	Laboratory analysis 2nd crop	Storage inspection 1st crop	Storage inspection 2nd crop
(1) Foundation seed farm:						
No. of seed farm inspected	6	7	6	7	6	7
No. of seed farm complying with the standards	6	7	5	6	6	7
No. of seed farm disqualified	0	0	1	1	0	0

Note: In the 1st crop, 24 varieties were examined, 2 were found disqualified.
In the 2nd crop, 30 varieties were examined, 1 was found disqualified.

	Field inspection 1st crop	Field inspection 2nd crop	Laboratory analysis 1st crop	Laboratory analysis 2nd crop	Storage inspection 1st crop	Storage inspection 2nd crop
(2) Stock seed farm:						
No. of seed farm inspected	73	111	46	95	57	95
No. of seed farm complying with the standards	57	95	33	73	57	95
No. of seed farm disqualified	16	16	13	22	0	0
(3) Extension seed farm:						
No. of seed farm inspected	2,160	2,952	520	1,560	0	0
No. of seed farm complying with the standards	1.963	2,496	264	998	0	0
No. of seed farm disqualified	297	456	256	562	0	0

3 Storage and Distribution of Pure Rice Seeds

The methods of storage and distribution of rice seeds vary with the levels of seed multiplication and also the length of time of storage required.

A. Storage and distribution of foundation seeds

The foundation seeds, after being properly sun dried to a moisture content not higher than 13%, are generally stored in wooden bins, installed in storage house of the District Agricultural Improvement Stations. Each wooden bin is 2.4 meters long, 1.06 meters wide and 2.7 meters high and is lined in the inside with galvanized iron sheet to keep the seed dry and to prevent damage from rats. The wooden bin has a lid on its top for loading seed and an outlet near the base at the front for unloading. It is installed 30 cm. above the floor in order to keep out moisture. Each wooden bin has a storage capacity of 2,400 kg. of rice seeds. Usually a series of wooden bins is installed in the same house for storing seeds of different varieties.

Before the planting season begins, the Prefectural Farmers' Association will take delivery of the foundation seeds by bringing empty jute bags to the DAIS and will take

back a certain amount of seeds according to the acreage of stock seed farm for planting. In Taipei area, the stock seed farm itself takes delivery of the foundation seeds directly from the Taipei DAIS.

B. Storage and distribution of stock seeds

After being properly sun dried to 13% moisture, the stock seed is kept either in wooden bins, as described above, or in smaller metal bins. The metal bin is either made of galvanized iron or aluminum sheet and has a capacity of 150 kgs. The bin is 90 cm. high with a diameter of 66 cm. and a rubber lined metal lid. The metal bin has several advantages, i.e., (1) it can be moved easily from place; (2) due to its smallness, it can be installed easily; (3) it is light in weight, rat-proof, and good for keeping seeds in relatively small amounts. Because of these reasons, it is popularly used in rural Taiwan not only for storing rice seeds but also for other crop seeds.

Stock seeds, after being certified and found up to the seed standards, will be bought up by the Prefectural Government. In taking delivery of the stock seeds, the Prefectural Farmers' Association or the Township Office will bring empty jute bags to the seed farm to collect the seeds and then haul the seeds by truck either to the Township Farmers' Association or to the Township Office. The extension seed farm operator will take delivery of the stock seeds from Farmers' Association or from Township Office.

C. Storage and distribution of extension seeds

The extension seed is kept mostly in jute bags. As the Ponlai rice varieties are generally non-sensitive to day length, they are planted both in the spring (first crop) and fall (second crop) seasons. The seed produced by the spring crop will be planted in the following fall, and *vice versa*, and so the storage period is comparatively short.

In the southern and central Taiwan (Yunlin, Chiayi and Tainan Prefectures), due to the insufficiency of irrigation water, rice is planted only once a year, at the time between the spring and the fall crop. Such rice crop is termed as intermediate rice crop. As the seed for intermediate rice crop will have to he stored for at least six months, a bowl-typed storage hut has been used by farmers for the purpose. Split bamboo strips are woven into a bowl shaped container which is seated on a heavy wooden base. The bamboo frame is then plastered, both inside and outside, with a mixture of lime, sand and mud. On one side of the storage, there is a small opening for loading and unloading the seed. Over the top there is a thatched roof. This construction will prevent the penetration of moisture, reduce the fluctuation of temperature and also keep out the rats. This storage hut usually has a capacity to store 3,000 kg. of seed, and can be erected by the farmers themselves in their yards.

In obtaining extension seeds, rice farmers bring in their own rice seeds to the seed farm operator in exchange of pure seeds. Sometimes the farmer takes pure seeds first from the extension seed farm and then returns his own seeds at a later date. The seed exchange rate will be 1 : 1 or 1 : 1.1 depending on the discretion of the operator. The seeds exchanged is hauled on a bicycle or on an ox-cart depending on whichever is available.

4. Concluding Remarks

The production and distribution of pure Ponlai rice seeds have been implemented quite smoothly in Taiwan. The certification of rice seeds has been started only from 1957. From then to date, the field inspection and storage inspection are carried out to cover all three levels of seed farms. Laboratory analysis is conducted on all foundation and stock seeds but only on one third of the extension seeds. The seed laboratory of the National Taiwan University is already under operation. The one of PDAF is under construction and expected to be completed in June, 1959. After its completion, with the assistance of the seven District Agricultural Improvement Stations, the certification work may be expanded to cover all the extension seed farms in Taiwan.

It may be stated that the success of this program lies in (1) the applicability of the system, (2) the careful selection of seed farm operators, (3) the provision of necessary physical facilities, (4) supervision of the management of the seed farms by the government, and (5) incentives to use pure rice seeds. Lack of any of these factors will make the program less successful.

METHOD AND TIME OF NITROGEN APPLICATION TO RICE

C.T. Abichandani

and

S. Patnaik*

A large number of manurial trials conducted on rice in India have shown that nitrogen fertilizers are the most effective for increasing rice yields almost under all soil conditions. Investigations conducted at Central Rice Research Institute, Cuttack, on low land clay soil of Mahanadi alluvium have however revealed that the efficiency of nitrogen fertilizers for increasing rice yields depends on form of nitrogen used and the level, method and time of application. In any rationalized fertilizer program in the country, all these factors have therefore to be taken into account to get the greatest economic returns from the use of fertilizers.

Form of Nitrogen

Abichandani and Patnaik (1958a) have discussed the results of manurial trials, conducted with different nitrogen fertilizers in India since 1938 and have shown that ammonium sulphate and ammonium chloride are, by far, the best fertilizers for increasing rice yields in India. Results with urea have not been very consistent. From trials conducted at Central Rice Research Institute, fertility value of urea generally ranks lower than that of ammonium sulphate. Recently conducted All India T.C.M. trials have, however, shown that response to urea varies considerably

* Division of Chemistry, Central Rice Research Institute, Cuttack, India.

from place to place but on an average, for all trials, it is nearly as good as ammonium sulphate.

Action of urea under flooded soil conditions has been recently examined at the Central Rice Research Institute, Cuttack, under pot conditions and it has been found that urea, well mixed with dry or semidry soil, about 24-48 hours before flooding, gives as good result as ammonium sulphate. Similar results on use of urea for rice crop have also been reported from Japan (Anon., 1958) where it is recommended that for maximum fertilizer efficiency, urea should be deeply placed immediately before irrigation. Application of urea after flooding has not been found as effective. Low efficiency of urea, reported in certain fertilizer trials in India may therefore be due to application of this fertilizer to the soil after flooding. In India, preparation of land for transplanting is invariably done when the lands are already flooded due to monsoon rains and deep applicationof urea to soil immediately before flooding is not quite practicable. It is therefore suggested that urea may be more profitably used under irrigated condtions. In rainfed flooded fields, ammonium sulphate and ammonium chloride may, as far as possible, be used. Fertilizers containing nitrate form of nitrogen are not found as efficient because of denitrification of nitrate in flooded sub-soil of rice fields.

Recently, ureaform, a slow acting fertilizer has been added to the list of nitrogen fertilizers. Experiments with ureaforms on rice crop are as yet not reported from India. Work has recently been taken up on these fertilizers at the Central Rice Research Institute, Cuttack. About sixteen ureaform products, with urea to formaldehyde ratio ranging from 1.5 to 3.0 have been prepared using different catalytic agents. These are at present being tested under pot culture conditions. Preliminary results on crop growth have shown that ureaforms with urea to formaldehyde ratio of 2.5 and above may prove as good as ammonium sulphate or urea for increasing rice yields.

Level of Nitrogen

40-60 kg. nitrogen per hectare has been generally accepted as a suitable nitrogen level for rice crop grown under most soil conditions in India. At certain locations, even 20-40 kg. nitrogen per hectare has been found adequate for increasing rice yields. Various rice growing areas in the country have worked out their own schedules of nitrogen level depending on local soil conditions, drainage etc.

It may however be mentioned that fundamental studies conducted under solution culture, at the Central Rice Research Institute, Cuttack (Tanaka *et al*, 1958) on the manuring of rice have shown that *indica* rice varieties do not respond well to high degree of nitrogen application as the *japonica* varieties do. It has been seen that at high nitrogen levels, nitrogen metabolism of *indica* varieties get disturbed at the reproductive stage and the varieties accumulate more soluble nitrogen, resulting in increased response in yield of straw and decreased response in yield of grain. It is therefore essential to determine optimum level of nitrogen necessary under different soil conditions, as high degree of manuring under certain soil conditions may result in low economic returns. At Cuttack, 40 kg. per hectare has been found as optimum level of nitrogen for increasing rice yields.

Method of Nitrogen Application

In rice soils, considerable fertilizer losses have been known to occur due to

surface run off, oxidation, leaching and denitrification in the reduced sub-surface zone of the flooded soil profile. The customary method of application of nitrogen fertilizer in India has been to broadcast the fertilizer on surface soil, 20-25 days after planting of the crop. Experiments conducted at this Institute (Abichandani and Patnaik, 1958 b) have shown that with this method of fertilizer application, about 20-40 per cent of applied nitrogen is lost by oxidation to nitrate nitrogen on the surface soil and its subsequent denitrification when leached down to the reduced sub-surface zone. Besides this, losses to the extent of 10-20 per cent occur in drainage waters, particularly in the event of a heavy rainfall within 24-48 hours after surface application of the fertilizer.

In trials conducted at this Institute, for the past 5-7 years, it has been seen that under low land water-logged conditions, these nitrogen losses can be checked and fertilizer efficiency increased if the fertilizer is placed in the sub-surface zone. By adopting this method, fertilizer efficiency has been increased nearly two fold and yield increase of 8-10 per cent over the customary surface application has been obtained. The following table shows the comparative effciency of surface and sub-surface placed ammonium sulphate applied at 22.4 kg. nitrogen per hectare, under various experiments conducted at the Central Rice Research Institute, Cuttack.

Table

Comparative efficiency of surface and sub-surfacc applied ammonium sulphate

Year of experiment	Season	Yield increase kg/ha. for each kg. of applied nitrogen: Surface applied	Sub-surface placed	Efficiency: Sub-surface / surface
1950-51	First crop	6.75	13.10	1.94
	Second crop	5.55	18.95	3.41
1951-52	First crop	6.75	11.35	1.68
	Cultivator's field trials	1.50	10.00	6.67
	Second crop	3.40	13.90	4.09
1952-53	First crop	8.60	15.70	1.83
1953-54	First crop	10.80	26.10	2.42
	Second corp	10.00	21.00	2.10
1954-55	First crop	8.50	15.90	1.87
	Mean	6.87	16.22	2.36

Adoption of sub-surface placement of ammonium sulphate both under broadcast and transplanted conditions has been suggested by Abichandani (1956). These have been tried and found useful for increasing fertilizer efficiency.

Time of Nitrogen Application

Next to method of application, time of application is also an important factor in determining the fertilizer response from a given level of nitrogen. Data on process of nitrogen assimilation by different varieties

during their life cycle have shown that rice varieties differ in their process of nitrogen uptake (Tanaka *et al*, 1959b). In early duration varieties, ear-initiation closely follows the maximum tillering stage and nitrogen uptake is a continuous process. In the medium and late duration varieties however, there is a time lag between the maximum tillering stage and ear-initiation. These varieties show two stages of vigorous nitrogen uptake, the first stage occurs upto maximum tillering stage after which the uptake slows down and again becomes vigorous with the onset of ear-initiation. Various stages of nitrogen uptake have also been studied in relation to their influence on yield components (Tanaka *et al*, 1959a). It is found that increased nitrogen uptake upto maximum tillering stage increases tillering capacity of the plant and determines effective panicle number. From ear-initiation to flowering, increased nitrogen uptake increases number of filled grains per panicle and from flowering to maturity, it increases 1,000 grain weight. Adequate nitrogen in soil at these different stages of plant development is therefore essential for maximization of yield.

Under field conditions in wet rice soils, surface run off, leaching and denitrification brings about losses of fertilizer nitrogen. Nitrogen applied at early stages of growth only, may therefore not be equally effective as, above factors, sooner or later, may deplete the soil of fertilizer nitrogen and need for second application may arise at the reproductive stage. Split application of nitrogen fertilizer, part basal at planting and part at the ear-initiation stage would therefore be a rational practice for increasing rice yields. Experiments conducted during the past five years at the Central Rice Research Institute, Cuttack (Vachhani and Mahapatra, 1959) have shown that for a long duration variety of 160 days, application of nitrogen in three splits, 22 kg/ha. basal at planting, 11 kg/ha. 30 days after planting and 11 kg/ha. 30 days before flowering increased fertilizer efficiency considerably and gave grain yield response of 1,021 kg/ha. as compared to 756 kg/ha., obtained with single basal application of 44 kg. nitrogen per hectare at planting.

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THE NEED FOR RICE VARIETIES WITH WIDER ADAPTABILITY

N. Parthasarathy
FAO Regional Rice Improvement Specialist, Bangkok

INTRODUCTION

Experience gained during the early years in rice breeding indicated that a single rice experimental station in a country could not cater to the need for the improvement of varieties for the large rice areas covering different ecological conditions. Rice stations for different ecological regions had to be started for the improvement of local varieties in the respective areas. At this stage, it was considered that the great varietal diversity in rice was due to its narrow or limited adaptability. The total number of recognized varieties is enormous running to thousands in most of the countries of S.E. Asia and the existing varieties in any one region are also unnecessarily large and still continue to exist because of the fancy of the farmer and many probably without any economic significance. Breeding work in the regional stations resulted to some extent in the reduction of the number of varieties but still the idea of finding the best variety for smaller units persisted with the result that the recommended varieties are still far too many for effective and practical implementation of seed programs. For instance, in India there are now more than 450 recommended varieties and in many countries the position is the same. In spite of the fact that rice breeding work started early in the century, the present position especially in countries of the tropical Asian region, is that roughly on the average only 15–20% of the rice areas are grown with improved varieties. As new varieties are bred there is no system for withdrawal of varieties released earlier and thus the number of recommended varieties is increasing. The full benefit of breeding can be achieved only if all the farmers grow improved varieties. The breeding program should be adopted to suit the facilities available for multiplication and distribution of the recommended varieties for the large number of different localities of a particular region. Not all the countries would be able to do this for the reason that they still lack either suitable extension organizations or that the stage of rural development has not yet reached the level at which the farmers could organize themselves for multiplication and distribution of the seed. In this connection, it has also to be mentioned that the breeders themselves in many cases are not in a position to advise exactly for which special areas a particular variety is best adapted because of the lack of variety trials in farmers fields.

Theoretically, the identification of the best adapted varieties for each ecological region would be the ideal for maximum production. The progress of rice breeding in Japan is in this direction and on the basis of climate and soil variations, the country is divided into 8 broad agro-ecological regions with a research station in each. The breeding work aims at finding the best varieties for any particular locality. There are favourable conditions in this country for the success of this program. The numerous farmers cooperatives and the high level of operation of the extension organization have contributed to the best utilization of the improved varieties.

Further, the uniformity of size and shape of the grain of japonica varieties has removed the difficulty of assemblage and milling for the markets.

Reduction of Varieties

In the initial stages of breeding, local collections provided material for selection work, though critical information as to performance or adaptability of varieties taken up for such work was not available. Generally, selection work was started with the varieties which were considered to be popular with the farmers in any particular region. Systematic regional trials of collections of the varieties grown in the country were taken up by Dr. Love in Thailand and Mr. Larter in Malaya to find out the varieties suited to the different regions in the country and in such tests one or two varieties were generally found to be cosmopolitan in that their performance in most of the regions was good indicating their wide adaptability character. Some examples of varieties of such adaptābility are Khao Ta Hueng in Thailand, Siam 29 in Malaya, G.E.B. 24 in Madras, India and Taichung 65 in Taiwan. Further progress in breeding consisted in the improvement of such varieties by using them as basic material for further breeding.

The early conception of the role of regional stations for breeding improved varieties for the respective ecological areas has now to be enlarged. These regional stations will have to be utilized for breeding varieties which could be suitable for wider adaptation and could be grown in a larger area covering more than a single region. An example, where such use is made of regional stations is in Java, Indonesia. From a common hybrid material, selection work was conducted in each of the 5 regional stations located in Java and the selections made at all the regional stations were tried in each of these stations. This was followed by numerous trials in farmers' fields extending all over Java. This procedure led to the evolution of varieties adapted the whole of Java covering distinct and different soil types and climates. The new improved varieties, *Sigadis* and *Bengawan* are outstanding examples of wider adaptation.

Rice breeding work in Taiwan is well organized in the matter of having fewer varieties and consequently it has one of the best seed multiplication and distribution programs. Rice breeding is carried out at the Main Agricultural Research Institute at Taipei as well as in 8 Regional or District Agricultural Improvement Stations. The varieties evolved after advanced tests in the district stations are taken for tests within each of the regions covered by the respective district and the number of tests in each district region is about ten. Promising varieties from each of the district tests are then taken for Province-wise testing in about 10 places scattered over the whole of the province. Sixteen to twenty varieties are selected for such a test. Due consideration is given to replace the older releases with newer and better varieties partly or wholly once in three years.

At the Sixth Session of the International Rice Commission held at Tokyo during October 1958, on the plans for future activities on Rice Production and Protection, this aspect of varietal improvement was emphasized as below:

> "Although in most countries participating in the Commission, rapid progress has been made in rice breeding, an excessively large number of rice varieties, improved and indigenous, is still in cultivation in many countries. These varieties are mostly grown in very restricted areas

due to their great sensitivity to environmental conditions. To increase the average yield of rice, it is important that the lower yielding types be eliminated thus reducing the total number of cultivated varieties. For this purpose varieties and selections must be tested under a wide range of conditions. Photo-periodic reaction is a character which so far has not been sufficiently emphasized; in order to produce varieties with great adaptability to varying day-lengths, fundamental investigations in rice physiology will be necessary. In view of the limited facilities available for this kind of research on the rice crop, these investigations might be carried out through arrangements with a research institute where the special facilities exist".

Ecological Factors

The significant environmental factors which affect the growth of rice are (1) water relations, (2) soil characteristics, (3) temperature - its seasonal and diurnal changes and (4) length of day during the growing season.

The first two factors are perhaps controllable to a great extent by irrigation and drainage and necessary soil amendments, such as fertilizers and organic matter. The last two, however, are dependent on climatic factors closely related to latitude location. In low latitude regions as the tropics, the monthly mean temperatures vary very little. The seasonal range is much less than in higher latitudes. From the nursery stage to the harvest, temperature does not vary very much in the lower latitudes and plants grow more or less under constant temperature conditions, while in the higher latitude areas, the temperature at the nursery stage is low and thereafter it rises rapidly reaching the maximum at flowering stage and then at the harvest time the temperature decreases to nearly the same level as at the beginning of the rice season. The length of day during the growth season also follows the same sequences as temperature. In the high latitude areas, the day during summer is much longer than at lower latitudes; the seasonal range in day length is comparatively within narrow limits in low latitude regions. The length of day to a great extent and temperature to some extent exert an influence on the maturity period of rice varieties.

Sensitivity to Photo-period

All rice varieties are sensitive to day length variations, although the response in some may be very slight. Broadly speaking, rice is regarded as a short day plant. Short day plants are those in which long dark periods (more than 12 hours) induce or accelerate flower initiation. Marked differences in the sensitivity to day length exist between varieties. The existence of period bound (time fixed) and season bound (date fixed) forms is based on these differences. There is a belief that, generally, most of the early varieties are less sensitive to photo-period than the late maturing varieties, but this is not sufficiently supported by fact. The *bulus* of Indonesia and the recent improved varieties from the same country are comparatively non-sensitive, though their maturity period is from 5-6 months. The maturity periods of some of the early non-sensitive varieties as the *aus* of Bengal and *yala* of Ceylon may not, if the temperature conditions are relatively constant, vary more than a week when such varieties are sown at different times during the year. In the case of late varieties the maturity period may vary considerably depending upon the time of the year at which they are sown. Such varieties may

not flower at all if the day length is extended by more than 50 minutes. In Japan, late varieties from the tropics do not flower at all under the natural day length conditions prevalent there.

The sensitivity to photo-period is to a certain extent limited to a particular stage of vegetative growth. At the seedling or nursery stage, length of day exercises little influence. The insensitive stage may be considered to exist from the start of sowing and germination and include early stages of growth up to transplanting after which the plant responds more clearly to photoperiod. There appear to be varietal differences in the length of this insensitive period. After formation of ear premordium which takes place about a month prior to the emergence of the panicle, the response becomes almost nil. An exhaustive and up-to-date review on photo-periodism in rice has recently been given by Best in Field Crop Abstracts (May 1959).

Photo non-sensitivity: Practical applications

Adaptability. Under tropical conditions, it has also been mentioned that temperature ranges throughout the year are fairly uniform but there is variation in day length hours, and the extent of such variation depends on the degree of latitude above or below the equator. At Bogor, Indonesia, the maximum day length of 12 hours 30 minutes is on December 21 and the shortest day length of 11 hours 47 minutes on June 21. Even this short range in day length has a profound effect on the maturity period of photo-sensitive *indica* varieties. Rice is cultivated here throughout the year by using low sensitive varieties like the *bulus* as well as low sensitive *indica* varieties like Tjina. The essential requirement for a breeding program in Java is the introduction of low photo-sensitivity in the improved varieties.

In monsoon Asia, the main rice season is from June to December and in this season, winter or *aman* varieties are grown. They are highly sensitive and so any delay beyond an optimum time in planting which may be due to late receipt of water or labour difficulties results in the reduction of vegetative growth and consequent loss in yield. Such losses may amount up to 30% or more. It would therefore be advantageous to evolve compartively non-sensitive varieties as in Java, as by the use of such varieties the losses due to delay in the planting season can be eliminated.

In countries where rice is grown twice a year, the low-sensitivity character has been found to be desirable as the same varieties could be grown in both the seasons. In Taiwan, the chief characteristic of Ponlai (*japonica*) varieties is that they can be grown both in the spring as well as in the fall seasons.

The comparatively non-sensitive character in rice varieties is useful not only for growing in different seasons in places where the temperatures are more or less uniform, but it is also extremely important in extending the adaptability of varieties to particular ranges of latitude in which the country or the rice region is located. It is this aspect which is considered to be very important in future breeding work. Non-sensitivity character is governed by genetic factors and therefore could be introduced in breeding through proper plant materials. In Indonesia, by hybridization of Latisail (*aman*, sensitive) with Tjina, (*indica* of low photo-periodic sensitivity) varieties like *Bengawan* have been evolved which have been found to be well adapted to different seasonal conditions. Similarly, *Sigadis*, another such variety, is assuming great importance with respect to wider adaptation, and this has been evolved by hybridizing a *bulu* non-sensitive variety

with an intermediate one (Blue Bonnet). In Taiwan, Taichung 65 has been found to have adaptation throughout the country. Varieties like Fortuna and Blue Bonnet (U.S.A.) show a great ecological adaptability in that they can be grown successfully in both the subtropic and tropics. Some of the selections from *indica - japonica* hybridization have also been found to be little sensitive and are being found suitable for second crop season in Malaya. Norin No. 1, a *japonica* variety evolved at North Japan, has been found to grow well in the *boro* season (November-April) at Dacca. Though Norin No. 1 is photo non-sensitive, but in view of its sensitivity to high temperature its performance is poor in the *aman* season. It is now found to grow successfully in the *boro* season at Dacca, when temperature conditions are more favourable. The degree of non-sensitivity of Norin No. 1 is such that long day conditions of 15 hours in Hokkaido, as well as the short day conditions in the *boro* season at Dacca, with a day length below 12 hours at the time when the crop is raised, have little effect on the maturity period.

Low photo–periodic sensitivity character is present in the *aus* and *boro* varieties in East Pakistan. These could be utilized in breeding *aman* varieties suitable to different conditions of water availability as well as for the greater range of latitude adaptability. In Taiwan, all breeding work revolves round widely adapted Taichung 65 for the improvement of other varieties resistant to blast, stiff-straw and responsiveness to fertilizers, etc.

Crop diversification. Another use to which non-sensitive varieties are put is in relation to crop diversification. It is strikingly illustrated in Kyushu, South Japan, where generally one rice crop is grown in summer, followed by wheat or barley in winter. Experimenting on varieties of Hokkaido, North Japan, where the growing season of rice is shorter, Dr. Komoda, Director of the Oita Prefectural Agricultural Experiment Station, Kyushu, found that a few varieties like NorinNo. 1, Rikku 132, Tomomashari, etc. could be grown successfully in the early part of the season and harvested by the end of July in South Japan, leaving thus a large portion of the warmer period for raising an intermediate crop before raising a cereal crop in winter. Some useful crops which could be grown during the intermediate season are autumn potatoes, forage crops like soya bean, oats, etc., or cash crops like vegetables and these could be harvested by the beginning of November. Another pattern will be the planting of late season rice by the begin ning of August, harvested by the end of October. The growing of early or late season rice has not only made possible an extra crop, but also removed the hazards of typhoon damage which usually occurs during September during which period the first crop would have been harvested and the second crop, even if it is rice, will be in the very early stages of growth. During 4 or 5 years nearly 12,000 ha. have been put to this type of farming and the number of dairy cows have increased considerably because of the fodder crops raised during the year.

Dr. Komoda in a personal communication on June 26, 1959 has written about further developments in sugar beet production :

> "In August this year approximately 300 ha. of fields will be switched over to sugar beets and it is planned that the acreage be increased to 1,000 ha. next year. The erection of a sugar refining plant is expected to be completed before November this

year. The principal varieties that are to be grown are G.W. 359 and KL-cercopoly. Hitherto, Hokkaido was the only place in Japan where sugar beet has been grown. The enterprise of ours is the very first trial of growing beets in the warm climate of South Japan. A great interest is being taken by the public in our trial. Our attempt at sugar beet crop in rotation has been rendered possible by the planting of rice in early season".

Summary

This note is intended to bring out the necessity for reducing the existing large number of recommended varieties and the importance of photo-periodism in future rice breeding in regard to the evolution of suitable high yielding varieties with adaptability for a wider range of ecological conditions, so that the difficulties in connection with seed multiplication and distribution of too many varieties in a region may be removed and increased production may result from the extensive use of fewer and better adapted varieties by the farmers. With adequate irrigation facilities, the land use can be made more efficient by the use of non-sensitive varieties for double cropping or for rotation with other cash crops.

The sources for the introduction of non-sensitive character are found in the different groups of rice, such as the *aus* of Bengal and East Pakistan, the *bulus* and the newly bred *indicas* of Java as well as some *japonicas* of Japan and Taiwan. Recently, at Tokyo University, Professor T. Matsuo was successful in obtaining photo-non-sensitive mutants by irradiation and this is yet another source for further development.

Emphasis has to be placed on this aspect of breeding in future rice programs in the countries. Fundamental studies on the physiology of photo-periodism and thermo-sensitivity in rice should be started or intensified in research institutes in order to provide our breeders with basic information for their work.

REVIEW OF "JAPONICA RICE, ITS BREEDING AND CULTURE"*

N. Parthasarathy

FAO Regional Rice Improvement Specialist, Bangkok

The publication of the book on "Japonica Rice" is welcomed with great interest, in view of the fact that highest rice yield is recorded in countries which grow *japonica* rice varieties. Considering the probable evolution of *japonica* from the *indica* which was grown from periods earlier than recorded history in the tropical regions of South East Asia, the progress made in the varietal improvement of *japonica* is impressive and remarkable. Great credit is due to the ingenuity of Japanese farmers who had provided the rich source of basic material through continued selection of varieties for adaptation to the rigorous climatic conditions of Japan. A recent

* "Japonica Rice, Its Breeding and Culture" by Isaburo Nagai, published by Yokendo Ltd., Tokyo, Japan (1959), pp. 843 with 12 plates and 132 text figures.

scientific advance in Japanese rice cultivation is its extension to the northern shores of Hokkaido, up to the latitude range of 45°N, where previously it was considered not possible to grow rice.

During the first half of the century, the progress of rice improvement in Japan has been rapid and this is mainly due to the pressing need of the country for the maximum utilization of agricultural resources for increasing rice production and provision of food for the rapidly increasing population. Scientific research both at agricultural research stations and universities has been harnessed towards this end. In fact, in no other rice growing country such a volume of rice research is in progress as in Japan. However, almost all the publications are in the Japanese language, and the knowledge of the valuable progress made was mostly confined to the country, and the author of this book is now to be congratulated for extending this knowledge to other rice growing countries through the medium of English. In fact, nearly half the bulk of references given in the book are publications in Japanese, and as the author himself has had considerable experience in rice breeding both in Japan and Korea, the value of the book is greatly enhanced as an authentic publication of Japanese contributions on this most important crop.

The subject matter of the book is dealt with in 12 chapters, and contains all the information available up to 1955 on climatology, ecology, embryology, genetics, breeding, physiology of growth and development, paddy soils and fertilizers, patterns of rice culture, and disease and pests.

Though the title of the book is "Japonica Rice", most of the available information on *indica* rices has also been brought out. Climatic relationship with the growing of rice in the different countries of Asia is given in terms of rain-fall, temperature and day-length.

In dealing with the dynamic factors of ecological differentiation, the author has rightly stressed on the photo-period and thermo-sensitivities of rice as perhaps the most important ones in the agronomic differentiation of cultivated varieties. Emphasis on promoting these aspects of rice research has been given in the recent Working Party meetings of the IRC in order to provide the rice breeders the basic information.

Regarding the ecological differentiation of *japonica* and *indica* rices, a broad classification into three groups had been made. In stressing the inter-relationships of these groups, work of Mizushima is quoted by the author in stating that there are several inter-grades one merging into the other and suggesting that "the cradle land of cultivated rice varieties might be somewhere in the Indian peninsula". Recent work of Dr. T. Morinaga strengthens this inference on the basis of extensive hybridization experiments and it is surmised that *japonica* now grown in the temperate zone may have originated from the *aus* group of rice grown in Bengal and East Pakistan. In this connection, it is interesting to note that very recently some 19 rice varieties collected during the exploratory survey of rice varieties in Orissa, resemble the *japonicas* in several morphological characters. Great interest has been shown by the Japanese workers in tracing the evolution of rice, and recently a project on investigations on the origin of rice has been started

with the aid of Rockefeller Foundation. Dr. Kihara, the well-known wheat botanist, is the leader of the Japanese team who have started the exploratory survey and study of the natural populations of wild species of rice both in Asia and Africa for collection of material and cytogenetical analysis.

In dealing with the inheritance of anthocyan colour characters as well as the kernel colours, available information on the bio-chemical basis for the expression of these characters is clearly indicated. The need at the moment for the advancement of genetical research is a uniform system of nomenclature of genetical symbols and the IRC is now seized with the matter for bringing this in a line with the recommendations contained in the recent report of the International Committee on Genetical Symbols and Nomenclature.

Rice breeders would find a detailed discussion on the breeding procedures as well as the basic requirements of genecological plant characters for rice regions in the various latitude classes. Definite objectives for breeding in relation to different cultural conditions in the growing of ricc are also listed. Inter-related to breeding is the physiology of growth and development and Japanese work is well in advance in this field and clearly indicates the necessity for advancing research in the physiology of *indicas*.

Though commercial fertilizers are contributing to increased production in Japan, it has been indicated from the results obtained in the experimental research stations that with a basic level of P_2O_5 and potash, increasing doses of nitrogen beyond 67 lbs. of nitrogen per acre lead to steady reduction in response, though the Japanese farmers apply larger quantities to the extent of 120 lbs. of nitrogen per acre. From the practical point of view for augmenting production, the author has rightly stressed that the lower response at higher levels of fertilizer application could be eliminated to a considerable extent by the proper adjustment of agronomic factors such as variety, control of irrigation, density of plant population, split application of fertilizers, etc. Physiological evidences are presented on the comparatively lower response obtained in the *indicas*, but a lot of work still remains to be done on varietal behaviour in *indicas* in relation to different levels of fertility before any valid conclusion could be drawn. More over, it would also be necessary to find the inter-relationship of the different agronomic factors in relation to fertilizer application. The phenomenal yields obtained by prize winning farmers in India emphasize the importance of proper agronomic technique in eliminating the lower responses from heavy doses of fertilizers.

Considering the great handicap of the language barrier, Dr. Nagai has really taken a significant step in bringing out this publication in English and in bringing out the next edition, no pains should be spared to correct errors in grammar and diction as well as the innumerable spelling mistakes. Those who are engaged in the rice improvement work as well as rice geneticists, physiologists and agronomists would find this book informative and interesting.

THE 1959 MEETINGS OF TWO WORKING PARTIES ON RICE PRODUCTION AND PROTECTION, AND RICE SOILS, WATER AND FERTILIZER PRACTICES OF THE INTERNATIONAL RICE COMMISSION TO BE HELD IN PERADENIYA, CEYLON

14 - 19 December 1959

At the kind invitation of the Government of Ceylon, the Eighth Meeting of the Working Party on Rice Production and Protection and the Seventh Meeting of the Working Party on Rice Soils, Water and Fertilizer Practices of the International Rice Commission will be held simultaneously from 14 to 19 December 1959, inclusive, at Peradeniya, Ceylon. The Director-General of the Food and Agriculture Organization of the United Nations has issued invitations to all twenty-seven member governments of the Commission to send highly-qualified scientists to attend these meetings.

The Provisional Agenda of these two Working Parties Meetings are given below:

Provisional Agenda

(For the Eighth Meeting of the Working Party on Rice Production and Protection)

Procedural Matters

1. Opening ceremonies (jointly with the Working Party on Rice Soils, Water and Fertilizer Practices).
2. Election of Chairman and Vice-Chairman.
3. Adoption of Agenda.
4. Election of the Drafting Committee.

Matters Relating to Rice Production and Protection

5. Final Report on the International Rice Hybridization Project.
6. Linkage studies and nomenclature of Rice.
7. Progress and future of the regional cooperative variety trials on Rice.
8. Observations on "Intermediate" rice varieties distributed in 1958.
9. Variety-fertilizer Interaction.
10. Review of diseases and pests of Rice in the field.
11. Assessment of field losses caused by diseases and pests.
12. Methods of forecasting outbreaks of diseases and pests of Rice in the field.
13. Methods of controlling diseases and pests of Rice in the field.
14. Review of Rice varieties showing resistance to diseases and pests.
15. Breeding and testing for resistance to blast and other diseases and pests.
16. Ways and means for reducing the number of Rice varieties.
17. Seed multiplication, certification and distribution of Rice.
18. World seed campaign in relation to Rice.

Procedural Matters

19. Other Business.
20. Date and place of next session.
21. Adoption of report.

Provisional Agenda

(For the Seventh Meeting of the Working Party on Rice Soils, Water and Fertilizer Practices)

Procedural Matters

1. Opening ceremonies (jointly with the Working Party on Rice Production and Protection).

2. Election of Chairman and Vice-Chairman.
3. Adoption of Agenda.
4. Election of the Drafting Committee.

Matters Relating to Rice Soils, Water and Fertilizer Practices

5. The N, P and K carriers and liming materials:
   (a) efficacy of the different materials.
   (b) time and methods of application.
6. Summaries of NPK fertilizer trials conducted during the last ten years.
7. Effects or deficiencies of trace elements.
8. Physiological diseases of rice.
9. Varieties - fertilizer interaction.
10. Simple fertilizer tests on cultivators, fields.
11. Soil sampling and analysis. Foliar diagnosis.
12. Classification of Rice Soils.
13. Optimum physical condition of Rice soils:
    (a) the optimum soil moisture content for tillage operations,
    (b) time, method and depth of tillage operation,
    (c) optimum soil aggregation for rice production,
    (d) drainage and aeration of Rice soils
14. Technical data for the Extension Services and for the cultivators.

Circulation of Second Edition of the "*Efficient Use of Fertilizers*"

15. Fertilizer supplies.

Procedural Matters

16. Other business.
17. Time and place of the next meeting.
18. Consideration of draft report.

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